

CLAIMS

What is claimed is:

1 1. A method for producing a lithographically printed image having a reduced critical
2 dimension, the method comprising the steps of:

3 (a) providing a semiconductor substrate optionally having at least a hardmask
4 defined thereon;

5 (b) providing an underlayer on said hardmask wherein said underlayer is
6 substantially free of any element that forms a non-volatile oxide;

7 (c) providing a PR layer on said underlayer, wherein said photoresist comprises a
8 material capable of forming a non-volatile, etch-resistant oxide;

9 (d) imagewise exposing said PR layer to radiation forming an image in said PR;

10 (e) transferring said image into said underlayer; and

11 (f) performing a controlled overetch of said underlayer.

12 plasma etching said underlayer, wherein the reactive species of said plasma
13 comprises oxygen; and

14 performing a controlled lateral thinning of said underlayer.

1 2. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said underlayer comprises less than 9% silicon.

1 3. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said underlayer comprises a tuned polymer.

1 4. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said underlayer is substantially free of any element that
3 forms a non-volatile oxide wherein said element is selected from the group consisting of
4 silicon, boron, phosphorous, germanium, and aluminum.

1 5. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said photoresist comprises an element capable of forming a
3 non-volatile, etch-resistant oxide selected from the group consisting of silicon, boron,
4 phosphorous, germanium, and.

1 6. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein the reactive species of said plasma comprises an element
3 selected from the group consisting of oxygen, hydrogen, fluorine, and chlorine.

1 7. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said underlayer comprises a tuned polymer comprising
3 carbon, hydrogen, and oxygen.

1 8. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said underlayer comprises an antireflective coating.

1 9. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said PR comprises a radiation-sensitive acid generator.

1 10. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said photoresist comprises a polymer having acid-cleavable
3 moieties bound thereto.

1 11. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said photoresist comprises a polymer formed by
3 polymerizing one or more monomers selected from the group consisting of acrylate,
4 methacrylate, hydroxystyrene optionally substituted with C₁₋₆-alkyl, C₅₋₂₀ cyclic olefin

5 monomers, and combinations thereof, the polymer having acid-cleavable moieties bound
6 thereto, wherein all such moieties are silylethoxy groups optionally substituted on the
7 ethoxy portion thereof with C₁₋₆-alkyl, phenyl, or benzyl.

1 12. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said radiation is selected from the group consisting of
3 electromagnetic radiation, 157-365 nm ultraviolet radiation, euv, electron beam radiation,
4 and hard and soft x-ray radiation.

1 13. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said radiation comprises ultraviolet radiation or extreme
3 ultraviolet radiation.

1 14. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said ultraviolet radiation comprises substantially
3 monochromatic radiation having a wavelength of from about 157 nm to about 365 nm.

1 15. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said ultraviolet radiation comprises substantially
3 monochromatic radiation having a wavelength selected from the group consisting of 157,
4 193, 248, 254, and 365 nm.

1 16. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said radiation comprises x-ray radiation.

1 17. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said photoresist comprises a stable, etch-resistant, non-

3 volatile oxide-forming material selected from the group consisting of silicon, phosphorous,
4 germanium, aluminum, and boron.

1 18. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said plasma comprises a reactive species selected from the
3 group consisting of oxygen, hydrogen, fluorine, and chlorine.

1 19. A method for reducing the critical dimension of a lithographically printed feature,
2 according to claim 1, wherein said tuned polymer comprises an organic polymer selected
3 from the group consisting of phenolic polymers, novolacs, epoxies, and diamond-like
4 carbon.

1 20. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 1, wherein transferring said image comprises plasma
3 reactive-ion etching.

1 21. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 18, wherein said reactive species comprise neutrals and
3 ions.

1 22. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 1, wherein performing controlled overetch comprises
3 controlling the etch rate.

1 23. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 22, wherein controlling said etch rate comprises adding a
3 non-reactive diluent gas to said plasma.

1 24. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 23, wherein said non-reactive diluent gas comprises
3 nitrogen and noble gasses.

1 25. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 22, wherein controlling said etch rate comprises regulating
3 process parameters.

1 26. A method for producing a lithographically printed image having a reduced critical
2 dimension, according to claim 22, wherein said process parameters consist of variables
3 selected from the group consisting of the duration of etch, the rf power, operating
4 pressure, gas flowrates, backside He pressure, electrode temperature, and wall
5 temperature.

1 27. The reduced critical dimension bilayer resist image comprising:
2 a semiconductor substrate;
3 an organic layer provided on said substrate; and a photoresist layer provided on
4 said organic layer, wherein said photoresist layer has a first image developed therein, and
5 wherein said organic layer has a second image, of reduced critical dimension and
6 congruent with said first image, developed therein.

1 28. A method of using a reduced critical dimension bilayer resist image comprising
2 the steps of:
3 (a) providing a substrate;
4 (b) forming a reduced critical dimension bilayer resist image on said substrate;
5 (c) transferring said image into said substrate forming a circuit image; and
6 (d) forming circuit element materials in said circuit image.

1 29. A method of using the reduced critical dimension bilayer resist image, according
2 to claim 25 wherein said circuit element materials comprise materials selected from the
3 group consisting of dielectric, conductor, semiconductor, and doped semiconductor
4 materials.

1 30. The semiconductor device fabricated using a reduced critical dimension bilayer
2 resist image.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100